AMERICAN SOCIETY FOR LASER MEDICINE AND SURGERY EIGHTEENTH ANNUAL MEETING SAN DIEGO, CALIFORNIA APRIL 5–7, 1998 ABSTRACTS

BASIC SCIENCE/SAFETY

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SKIN COOLING ANALYSIS BASED ON *IN VIVO* EPIDERMIS TMPERATURE MEASUREMENTS.

Boris Vaynberg PhD, Michel Kreindel PhD, Vered Scharf*, Ophir Eyal*, Prof. Abraham Katzir*, ESC Medical Systems, Yokneam, Israel, *Tel-Aviv University, Tel-Aviv, Israel

Treatment of skin lesions using pulsed light sources requires transmission of the light through the epidermis. In most cases (other than the treatment of epidermal pigmented lesions) it is critical to keep the epidermal temperature to a level lower than the its damage threshold. Control of the epidermis temperature can be achieved by means such as proper pulse timing taking advantage of the size of the epidermis. Temperature relaxation in the epidermis was measured by using a radiometric technique for human skin *in vivo*. Results of these measurements combined with theoretical analysis of the experimental data based on the solution of the heat conductivity equation will presented. A model of temperature behavior in the epidermis that was used for the analysis of different methods of the epidermis cooling will also be presented.

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CRYOGEN SPRAY COOLING OF HUMAN SKIN UNDER VARIOUS EXPERIMENTAL CONDITIONS

B. Anvari[1,2], B. Ver Steeg[2], T. E. Milner[1] B. S. Tanenbaum[2], and J. S. Nelson[1]

[1]Beckman Laser Institute and Medical Clinic, University of California, Irvine, CA

[2]Department of Engineering, Harvey Mudd College, Claremont, CA

Purpose: To investigate the effects of: 1) ambient humidity level; 2) spraying distance; and 3) cryogen compound during spray cooling of human skin.

Methods: Selected skin sites of volunteers were sprayed with R-134A (boiling point (BP) ≈ -26 °C), R-407C (BP ≈ -43 °C), and R-404A (BP ≈ -48 °C) under various ambient humidity levels and spraying distances. Radiometric surface temperature in response to cryogen spray cooling was measured by a HgCdTe detector. An algorithm was used to compute the spatial temperature distribution from temporal infrared measurements.

Results: 1) Increased ambient humidity level resulted in more ice formation on the skin surface without altering the surface temperature during a spurt; 2) Spraying distance considerably altered the surface temperature; and 3) BP of the test cryogens did not directly affect the measured surface temperature.

Conclusions: Understanding the thermodynamics of cryogen spray cooling is essential for optimization of treatment parameters, and design of delivery systems when utilized in conjunction with various laser mediated dermatological procedures.

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DYNAMIC CHANGES IN THE ABSORPTION COEFFICIENT OF WATER DUE TO IRRADIATION FROM Q-SWITCHED Er:YAG LASER

Ramesh K. Shori, Joseph T. Walsh, Jr., Oscar M. Stafsudd*

Biomedical Engineering Dept., Northwestern University

*Electrical Engineering Dept., UCLA

Er:YAG lasers emitting 2.94-μm radiation are now being used for cutaneous surgery. The understanding of Er:YAG laser-tissue interactions has been based upon the low-intensity absorption coefficient of water. A Q-switched Er:YAG laser was used to measure

*The author(s) acknowledge that proprietary disclosure is required for material presented in the abstracts denoted by an asterisk.

the transmission across water layers varying in thickness from 2-6 μm. The incident radiant exposure was varied from ~0.01 to ~2.5 J/cm^2. From the measured transmission data, we applied a dynamic, finite-difference absorption model to calculate the spatially and temporally varying absorption coefficient. The results show that whereas the low-intensity absorption coefficient is ~13,000 cm^{-1}, which is consistent with previous results, at the highest radiant exposures the absorption coefficient decreases to approximately 1500 cm^{-1}. Consequently, the penetration of 2.94-μm radiation into water, and therefore tissue, is much greater than previously predicted. These results will aid the understanding of the mechanism of laser-tissue interactions in applications such as skin resurfacing and corneal sculpting using Er:YAG lasers.

Photothermal treatment of superficial blood vessels requires a high degree of selectivity in heating of the vessel relative to the epidermis and surrounding tissue. Direct measurement of light absorption in vessel is difficult. In the present study the light reflection spectra of a normal skin and of a skin with large vessels was measured as a function of wavelength in the range of 500 to 1000nm and was used to directly analyze light absorption in large vessels. We have experimentally confirmed that wavelength shorter than 600nm are appropriate for the treatment of shallow vessels while longer wavelength provide more light absorption by deeper vessels. Optimal light wavelengths ranges and pulse parameters for the large vessel treatment will be discussed.

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OPTICAL PROPERTY CHANGES OF LIVER TISSUE DURING HEAT EXPOSURE IN LASER-INDUCED THERMOTHERAPY

J.-P. Ritz[1], A. Roggan[2], C.Isbert[1], D.Albrecht[1], C.Germer[1], H.J.Buhr[1], Dept. of General Surgery[1], Dept. of Laser Medicine[2], University Hospital Benjamin Franklin, Freie Universität Berlin, Germany

Laser-induced thermotherapy (LITT) is a promising treatment for irresectable liver tumors. For predicting the effects of laser applications and optimizing irradiation planning in LITT the knowledge about light distribution in tissue, optical tissue properties (absorption, scattering, anisotropy, penetration depth) and their continuous changes during therapy is indispensable. Measurements of optical properties were performed with a double-integrating-sphere-system and a laser diode (830nm). Porcine liver tissue samples were examined in a native state (35°C) and after exposure to varying temperatures (45°C to 80°C).

Rising temperature was accompanied by a decrease in the absorption coefficient and anisotropy factor and an increase in the scattering coefficient. These changes were only signifcant in the temperature range of 50° to 65°C ($p<0.01$). The optical penetration depth decreased from 3.11 mm in the native state to 1.67 mm at 65°C ($p<0.01$). Above 65° there was no significant change in the optical tissue properties.

Temperature	*35°*	*45°*	*50°*	*55°*	*60°*	*65°*	*70°*	*80°*
Absorption(1/mm)	0.068	0.06	0.06	0.051	0.041	0.034	0.031	0.03
Scattering (1/mm)	6,72	6,75	9,02	11,85	12,57	13.73	13.1	13.47
Anisotropy	0.94	0.88	0.86	0.83	0.79	0.75	0.73	0.68
Penetr.depth(mm)	3.11	2.57	2.11	1.81	1.75	1.67	1.7	1.61

The optical properties of liver tissue change significantly under the influence of tissue heating resulting in a decreased optical penetration depth. These changes mainly occur in the temperature range of 50°C to 65°C corresponding to protein denaturation. In order to provide a safe and effective procedure it is recommended to adapt laser power to the actual penetration depth during therapy.

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OPTIMAL WAVELENGTH RANGE FOR PHOTOCOAGULATION OF LARGE BLOOD VESSELS

Michael Kreindel Ph.D., Boris Vaynberg PhD,
ESC Medical Systems, Yokneam, Israel

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LASER-INDUCED THERMOTHERAPY (LITT) FOR TREATMENT OF MALIGNANT LIVER TUMORS: THE INFLUENCE OF HEPATIC PERFUSION AND APPLICATION MODE ON LESION SIZE – AN EXPERIMENTAL STUDY.

D. Albrecht, C. Germer, J. P. Ritz, C. Isbert, A. Roggan, H.J. Buhr.
Dept. of Surgery, Universitätsklinikum, Benjamin Franklin, Freie Universität Berlin, Germany

Laser-induced thermotherapy is a procedure enabling the destruction of malignant liver tumors. The aim of the present animal experimental study was to investigate the effect of temporarily interrupting hepatic perfusion as well as the application mode on inducible volume using a specially designed application system. Experiments were carried out using a Nd:YAG laser at a wavelength of 1064 nm. A special multifiber optical component was used. Ten German hybrid pigs served as the experimental animals, and video-assisted laparoscopic was used. Laser power input was 38 W leading to an output of 6 W at the tip of each of the 4 applicators. Application time was 540 sec. All animals were sacrificed four hours after the end of application, and the livers were removed for histological examination. With a single application, a mean lesion volume of 2,5 cm^3 resulted from a total applied energy of 4356 J. Under temporary occlusion of hepatic circulation, there was a lesion volume of 7,4 cm^3 with the same total applied energy ($p<0.01$). Multifiber laser application with hepatic circulation led to four individual tissue lesions with a mean volume of 14,6 cm^3. During interrupted circulation, overlapping tissue lesions with a mean volume of 50,3 cm^3 were induced ($p<0.01$). Microscopic examination showed that the rim seen macroscopically was identical. Just as the application mode, hepatic circulation is a statistically significant parameter on the inducible lesion volume. The interruption of liver perfusion during laser application led to a significant increase in volume of the hyperthermically induced tissue lesion irrespective of the application mode. The dimensions of necrosis achieved could, if applicable to tumor tissue provide a method of treatment of greater human liver lesions.

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OPTICAL AND THERMAL PROPERTIES OF HAIR

Michael Kreindel, Ph.D. and Zvi Ladin, Ph.D.
ESC Medical Systems, Yokneam, Israel

The optical properties of different colored hair were

measured and compared to those of other skin components. Measurements of the thermal relaxation time of hair imbedded in different media were conducted. Results suggest that the optimal heating of hair requires pulsing of light and that the optimal pulse duration for the treatment of hair bulbs located in the dermis, should be shorter than 20ms. Follicles located in the subcutaneous fat, can be treated by light pulses that are up to 100ms long.

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HAIR REMOVAL WITH THE PHOTODERM^R VL AS AN INTENSE LIGHT SOURCE A HISTOPATHOLOGICAL STUDY

C.A. Schroeter, MD, Medical Centre Maastricht, Becanusstraat 17, 6216 BX, Maastricht, the Netherlands

The permanent removal of hair is of great clinical and social interest and until now no efficient technique without serious side-effects such as scar formation and hyperpigmentation was available. In this experimental study we describe the permanent removal of hair without serious side-effects by means of non-laser incoherent emitted intense light source, produced by the PhotoDerm^R VL. To investigate microscopically the alterations of the hair follicles as pathological substrates of this treatment, a pig model was chosen. Pigs were treated with the PhotoDerm^R VL at different pulse times, pulse modes and energy levels. Biopsies were taken at different time intervalls from 3 h up to 106 d after the initial treatment and routinely processed. Microscopical analysis showed first lysis of the cells of the hair follicle, followed by coagulation necrosis starting 3-48 h after the initial treatment. After 1-4 wk the necrotic hair cells in the hair follicles gradually were removed by giant body granulomas which were located in the centre of the follicle. No inflammatory reaction occurred in the surrounding dermis. Connective tissue gradually replaced the destroyed hair follicle. Four to 6 wk later there were no remnants of hair follicles. Histologically there were a few epidermal (10%) and dermal (4%) side-effects. The best parameters for the PhotoDerm^R VL out of our experimental study being used are a cut-off filter with a wavelength of 590-nm, an energy of 30 J/cm^2, a pulse time of 5 msec and a single pulse as pulse mode. These findings indicate that hair removal by selective photothermolysis is possible and permanent.

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RADIATIVE TRANSPORT MEASUREMENTS IN SOFT TISSUE

Richard Scheps, Leon Goldman, Foundation for Laser Subsurface Imagery, San Diego, CA

We present a study of the parametric variation of laser radiation through soft animal tissue. The adjustable parameters include the laser wavelength, fluence, pulse length and sample thickness. Samples used were thin slices of turkey breast tissue. The primary motivation for this work is to determine whether pulse length is an important factor in determining the optical flux penetration depth in soft tissue. A second goal of the study is to provide a quantitative measure of laser optical penetration in soft tissue as a function of laser wavelength, incident fluence and sample thickness. Although optical transmission curves for hemoglobin and melanin for example are well-known, the attenuation of laser radiation in soft tissue is due to multiple scattering as well as absorption. There is a complex relationship between fluence propagation and sample thickness. This issue is addressed using radiative transport theory for scattering in random media.

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Possible mechanism involved in weal and flare reaction after laser treatment

B. Algermissen[1], U. Müller[1], B. Hermes[2], C. Philipp[1] and H.-P. Berlien[1].

[1]Dept. of Lasermedizin, Krankenhaus Neukölln, Rudower Str. 48, D-12313 Berlin, Germany, [2]Dept. of Dermatology, Krankenhaus Neukölln, Berlin, Germany

After only a few minutes following laser treatment we observed a variety of weal and flare reactions, without itching, in both the treated area and in their surroundings. These reactions were induced largely independently of wavelength with argon, copper, flashlamp pumped dye lasers but above all by the Nd:YAG laser. In this study we attempted to evaluate pharmacological effects and to shed light on the mechanism involved. The first step was to irradiate the normal skin of 10 volunteers with an argon laser (Aesculap Meditec, Germany, 2 W energy, wavelength 514 nm, 1,0 mm focus, 0,1 sec. iimpulse duration) after the topical application of triamcinolone creme, EMLA®creme and systemic application of acetylsalicylic acid (1000 mg per os) and Lisino® (loratadine 20mg per os). The sizes and the time dependence of the weal and flare reactions were measured semiquantitatively and photodocumented. Under these treatment modalities we found in 18 from 20 volunteers a significant abolishment of erythem and flare only for EMLA®creme, suggesting that some depletion in the nerve endings seemed to be involved. Therefore we pre-treated the laser areas 2 times a day for 3 days for depletion of the C-nerve fibres and found in 11 out of 11 volunteers no erythem and flare reaction 5 min. postirradiation in comparison to the control. Another explanation of the weal and flare reation could involve the degranulation of mast cells. In skin biopsies pre- and postirradiation we found no mast cell degranulation close to the coagulation zone.
Our data suggest that the weal and flare reactions shortly after laser treatment were generated as a result of depletion of neuropeptides from the C-nerve fibres of the skin.

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ULTRASTRUCTURAL AND IMMUNOHISTOCHEMICAL COMPARISON OF CO_2 RESURFACING LASERS

Author: Christopher B. Harmon - Birmingham, Alabama
Co-Authors: Brian Zelickson - University of Minnesota; Mark Pittelkow - Mayo Clinic; Elizabeth McBurney - Tulane University School of Medicine; John Yarbrough - Tulane University School of Medicine

The purpose of this study is to better understand the events that occur following CO_2 laser resurfacing. More specifically, this is a side by side comparison of the ultrastructural changes and immunohistochemical staining patterns following facial resurfacing with the Coherent Ultrapulse Laser and the Palomar TruePulse CO_2 laser. Study participants received full face laser resurfacing treatments with one of these two lasers and concomitant treatment of the right

preauricular area with the opposing laser. Skin biopsies were taken of the right and left preauricular areas to compare the tissue response to each of these lasers. Ten biopsies were taken from each patient over a 6 month period; then submitted for electron microscopy and immunohistochemical staining. Ultrastructural changes of the basement membrane components: lamina densa, anchoring fibrils, basal cell membranes and hemidesmisones were studies and photographed. Ultrastructural observation was also made of the collagen fibers, elastic fibers and superficial dermal vasculature. At the light microscopic level, a portion of each biopsy specimen was stained with routine hematoxylin and eosin stains. Another portion of the biopsy was stained with monoclonal antibodies for the wound healing molecules: tenacin, beta interins, fibronectin, and laminin. Eulex and CD34 were also used to stain the superficial blood vessels. Photographs and descriptive reports with semi-quantitatve immunoreactivity ratings demonstrated significant ultrastructural and immunohistochemical differences.

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RESOUNDING RESURFACING: THE AURAL THREAT OF THE ER:YAG LASER?

Tope WD, Hunter LL.

The advent of the Er:YAG laser in resurfacing human skin has left patients' and physicians' ears ringing. An often audibly uncomfortable report accompanies laser pulse impacts. To determine whether these constitute a significant long term threat to audition we tested the noise levels created by experimental and practical use of the Er:YAG laser (CrystalLase 2940, SEO Medical, Orlando, FL).

Our experimental set up consisted of continuously renewed normal saline soaked cotton gauze. This allowed us to assess the noise generated by absorption of Er:YAG laser energy (2940 nm, 250 µs, 8 - 28.7 J/cm^2, 2 - 4 mm spot, 4 Hz) at physiologic H_2O concentration. Peak sound pressure level (SPL) coinciding with laser impacts were determined for frequencies detectable to the human ear (80 - 8000 Hz) using an impulse precision sound level meter meter fitted with a 1/3 octave filter set and a pressure sensitive microphone (Bruel & Kjoer, Copenhagen). The effect of variable pulse energy, spot size, and distance from the laser impact site were tested.

Using a fixed 2 mm beam at a distance of 2 cm, variable fluences (9.6, 19.1, 28.7 J/cm^2) created 59 - 79 dB peak SPL. Peak SPL did not vary significantly over this range of fluences. Using a fixed fluence (8.0 - 9.9 J/cm^2) at 2 cm and variable beam diameter (2, 3, 4 mm) created 59 - 88 dB peak SPL. Peak SPL demonstrated an upward trend with increased beam diameter. Peak SPL created by laser pulses from 2 - 90 cm from the impact site decreased from 13.4 - 25 %. Representative measurements were confirmed with the same meter equipped with a field responsive microphone and with intraoperative readings.

Peak SPL occurred at the largest spot size and over 1000 - 2500 Hz.

Reverberation of sonic pulses off of hard surfaces in the operative suite accounts for the failure of SPL to fall off with distance from the source as predicted by an inverse square law. The short exposure time and SPL generated by the Er:YAG laser during a typical resurfacing case should not prove of significant harm to the hearing of providers or patients. Use of appropriate ear plugs or personal headphones should provide for a less aurally noxious resurfacing experience.

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C0^2 Laser Physics & Tissue Interaction in Skin.

Jamcs E. Fulton, Jr., Paul K. Shitabata, Fulton Skin Institutc, Newport Beach, CA.

Background: The theoretical model of C0^2 laser tissue interaction appeared too simplistic. To explain the reactions seen in skin, a more complex model was needed.

Objective: To correlate the clinical-histologic patterns of C0^2 laser tissue interactions.

Method: The UltraPulse C0^2 laser was used on normal and pathologic skin conditions. Clinical observations were correlated with histologic examinations of biopsies.

Results: It was possible to demonstrate wide-spread cavitation at the dermal-epidermal junction 2-3 diameters beyond the actual spot of C0^2 laser contact with the skin. Dermal heat damage reflected as homogenization of collagen 1-2 diameters beyond the point of laser contact. This flow of energy laterally at the dermal-epidermal junction and vertically down the skin follicles was both clinically beneficial and detrimental. Beneficially, superficial skin lesions separated at this junction were easily removed. The heat coagulation of the dermis facilitated lesion removal without bleeding. The clinician had a better view of the pathology and could find focal zones of deeper pathology that could be easily re-treated. Detrimentally, this extended damage delayed wound healing and led to persistent erythema.

Conclusion: These clinical-histologic correlations have provided a better understanding of C0^2 laser tissue interactions in skin. It has been possible to take advantage of these findings or remove pathologic skin conditions more efficiently. Occlusive dressings facilitate would healing and alleviated persistent erythema.

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MICROBIOLOGIC ACTIVITY IN LASER RESURFACING PLUME AND DEBRIS

P. J. Capizzi, M.D., Mayo Clinic, Rochester, MN
R. P. Clay, M.D., Mayo Clinic, Rochester, MN

To analyze potential bacterial and viral exposure to OR personnel posed by the laser smoke plume in the Tru-pulse carbon dioxide laser resurfacing.

Thirteen consecutive patients underwent CO2 laser resurfacing. A Hepa filter in the smoke evacuator was used to collect specimens of laser plume smoke for viral and bacterial cultures. The study was controlled by using a second filter via the smoke evacuator exposed to room air.

Thirteen patients had bacterial, viral, and control culture sent for a total of 65 specimens. In the control group, no growth was noted in all specimens. Five of thirteen bacterial cultures resulted in growth of coagulase negative staphylococcus. Two of the five positive specimens in addition grew with a single specimen of Corynebacterium and Neisseria, respectively.

1) Biologically active materials such as bacteria survive in laser smoke and produce a potential for exposure of operating room personnel to this material. 2) Smoke from laser resurfacing represents a safety hazard which must be managed via a high flow smoke evacuator.

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Collagen Shrinkage Using the C0^2 UltraPulse.

James E. Fulton, Jr., Thomas Barnes, Fulton Skin Institute
Newport Beach, CA

Background: The UltraPulse CO^2 laser has proven useful for skin resurfacing. The modality can be less penetrating than chemical peels and more accurate than dermabrasion.
Objective: To demonstrate the additional benefit of dermal remodeling (selective dermaplasty) of skin lesions, scars, grafts, folds and eyelids.
Methods: The True-Spot and the CPG handpieces were used with the UltraPulse CO^2 laser at 250 to 350 millijoules to remodel tissue. Usually three to four passes were adequate to vaporize tissue and shrink collagen.
Results: A rejuvenated earlobe, eyelid or forehead was produced in a predictable fashion. The tissue irregularities of scars, dog-ears or trap door deformities were reduced and remodeled.
Conclusion: Dermal remodeling (selective dermaplasty) with the UltraPulse CO^2 laser has proved a useful tool to remodel the skin. Areas such as the earlobe, the forehead, the eyelids of skin lesions can be vaporized to develop a more youthful appearance. We find this a useful addition to the armanentarium of the cosmetic dermatologist.

BIOSTIMULATION

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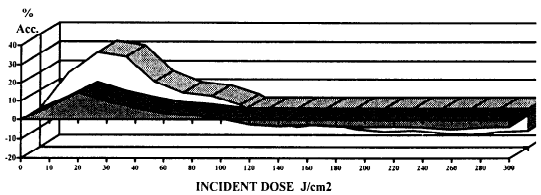
STIMULATION AND INHIBITION EFFECTS OF Kr. LASER FOR WOUND MANAGEMENT'S

FAROUK A. H. AL -WATBAN
King Faisal Specialist Hospital & Research Centre
P.O. Box 3354, Riyadh, Saudi Arabia

The investigation of wound management's stimulation and inhibition effects on rats using Kr. laser (wavelength 670 nm.) for 0.39 cm^2 wound size, Laser spot size 4 cm^2, 3 time per week treatment schedule, 35&71 mW/cm^2 incident dose rate, and up to 300 J/cm^2 incident dose (Exposure time up to 70 min.) were studied . The results showed that the optimal acceleration were 14.54% in healing days and 30.41% in size reduction at the incident dose of 20 J/cm^2. The inhibitory effect of low power Kr. laser showed the zero bioactivation at the incident dose of 100 J/cm^2 and the maximum deceleration was -4.08% and -13.7% in healing days and size reduction, respectively, at the incident dose of 260 J/cm^2 in this study. Sprague-Dawley rats with 78.34% laser skin reflection rate were effecting the dosages. The actual dose including the skin absorption were 4.03, 20.14 and 52.37 J/cm^2 for optimal stimulation, zero bioactivation and maximum deceleration respectively.
In comparison with other lasers, Kr. laser wound stimulation's compatible with the absorption spectrum of fibroblast. Equivalents to HeCd laser, lower than HeNe laser by 15 &20%, lower than Ar., & GaAlAs (780 nm.) by 8 &12%, and lower than GaAlAs (830 nm.) by 6&9%, for healing days and size reduction respectively.



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REDOX ABSORPTION CHANGES (λ=500-860 nm) of HeLa CELL MONOLAYER UNDER IRRADIATION WITH SEMICONDUCTOR LASER at 670 or 820 nm

T. KARU[a], N. AFANASYEVA[b], S. KOLYAKOV[b], L. PYATIBRAT[a] *[a]Laser Technology Research Center of the Russian Academy of Sciences,, Troitsk, Moscow Region, Russian Federation; [b]Institute of Spectroscopy of the Russian Academy of Sciences,, Troitsk, Moscow Region, Russian Federation.*

Principal action mechanisms which have been proposed to explain low-power laser effects on cellular level include generation of singlet oxygen (Karu et al., 1984), changes in the redox properties of the respiratory chain components following photoexitation of their electronic states (Karu, 1988), localized transient heating of absorbing chromophores (Karu et al., 1991) and increased superoxide anion production (Karu et al., 1993). The purpose of the present work was a study of redox absorbance changes in living cells with an aim to investigate the mechanisms of low-power laser radiation on cellular level. For this purpose, a sensitive method of multichannel registration of absorption of a cell monolayer in the range 500-860 nm was developed. The absorption of HeLa cells monolayer was recorded before and immediately after the irradiation (670 or 820 nm, 6.3×10^3 J/m^2, 10 s). Results of comparison of the absorption spectra of the HeLa cells and action spectra concerning the same cells (dependences of DNA and RNA synthesis rate on the wavelength) allows us to conclude that both absorption and action spectra have similar bands at 670-680 and 770-780 nm. These bands belong supposedly to chromophores Cu_A (in oxidized state) and Cu_B (in reduced state) of cytochrome c oxidase. It was found that the irradiation at both wavelengths (670 and 820 nm) caused an increase in absorption band at 670-680 nm and a decrease in absorption band at 770-780 nm, the kinetics of the processes being different for 680 and 820 nm irradiation. It is possible to conclude that the first experimental results of measurements of redox absorbance changes in living cells indicate that the mechanism based on changes in redox properties of cytochrome c oxidase might be crucial in explaining of low-power laser effects.

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THE INFLUENCE OF LOW LEVEL INFRA RED LASERTHERAPY ON THE REGENERATION OF CARTILAGE TISSUE

P. Lievens, E. Lippens
Vrije Universiteit Brussel, Belgium

Purpose
This study concerns the influence of Lasertreatment on the regeneration process of cartilage tissue. There is no need saying that the regeneration of cartilage tissue is a very big problem in rheumatic diseases for example. The lack of blood supply is one of the most important factors involved. Lots of previous publications give us prove of the regeneration capacities of Lasertherapy (in wound-healing, bone repair etc.)
Methods
In this study we have choosen to experiment on cartilage tissue of the ear of mice. We are aware of the fact that the elastic cartilage tissue of the ear is not totally comparable with the hyaline cartilage of articulations. For technical reasons however and because of the fact that the chondrocytes are comparable we decided to use mice ears in our experiment. A 0.4 mm hole was drilled in both ears on 30 mice. The right ears remain untreated while the left ears were treated daily with Infra Red Laser (904 nm) for 3 minutes. Macroscopical as well as histological evaluations were performed on the cartilage regeneration of both ears.
Results
- After one day postsurgery no differences were found between the irradiated and the non irradiated group.
- After the second day, only in the irradiated group, there is a clear activation of the perichondrium.

- After four days, there is a significant ingrow of the perichondrium into the dril hole in the experimental group and there is only an active perichondium zone in our control group.

Conclusion

IR laser has an influence on cartilage regeneration.

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LACK OF EFFECT OF LOW INTENSITY LASER THERAPY (890NM) UPON A RADIATION IMPAIRED MODEL OF WOUND HEALING IN MURINE SKIN

Lowe, A.S., Walker, M.D., Baxter, G.D., Kennovin G.D., Leek, M., Hirst, D.G. Rehabilitation Sciences & Radiation Sciences Research Groups, Schools of Health Sciences and Biomedical Sciences, University of Ulster, Jordanstown, N. Ireland; Smith & Nephew Group Research Centre, Heslington.

In the present study, the effect of low-intensity light therapy (890nm) upon a radiation impaired wound model in murine skin was investigated

Male Balb/c mice (n=50; age matched at 12 weeks) were included in the current study and randomly allocated to 5 experimental groups (n=10 each group). In Group 1, mice were left untreated; in Groups 2 to 5 a well-defined area on the dorsum was exposed to 20 Gy (Siemens Stabillipan X-ray machine). Seventy-two hours post-irradiation all mice were anaesthetised and a 7mm square area wound made on the dorsum, (corresponding to the previously irradiated area). All wounds were videotaped alongside a marker scale (3 times weekly) until closure was complete. In Groups 3, 4 and 5 mice were treated with low-intensity irradiation (0.5, 1.5 and 4J/cm^2 respectively) 3 times weekly using a 890nm multidiode (n=60) array unit (270Hz; 300mW; Anodyne, Denver, CO, USA). Subsequently, wound area was measured from video using an image analysis system (Fenestra 2.1). Statistical analysis using analysis of variance showed that prior irradiation with X-ray doses of 20Gy caused a significant ($P \leq 0.04$) delay in the rate of wound healing by day 9 when compared to the untreated group (at day 9, Group 1; 0.20±0.05, Group 2; 0.40±0.03). However, treatment with all three radiant exposures (0.5, 1.5 and 4J/cm^2) had no effect upon the rate of closure in this animal model. These findings provide little evidence of the claimed stimulatory effects of this modality at the parameters indicated upon wound closure *in vivo*.

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The Bioeffect of Lipohemia Rabbits Irradiated in Oral Mucosa with 650nm Diode Laser Accompanied Oxygen Inspiration and Clinical Application

Fu-Shou Yang, Cheng Liu, Jinxiang Tang, et al.
Shanghai Seamen's Hospital, Dep. of Laser Medicine

ABSTRACT

The study on irradiating in oral mucosa of rabbit -s with 650nm diode laser(accompanying with oxygen) and clinical application has been reported in this paper. The results of animal experiment swowed: The obvious decrease of cholesterin and triglyceride has been found among those highly lipohemia rabbits in the experiments of 650nm diode laser irradiating accompanying with oxygen, as well as the parameters of hemorheology obviously being improved, as compared with highly lipohemia rabbits un-irradiating, the statistical analysis showed : $P < 0.01$. In the meantime, the observation of histopathology showed, the lipide decreasing in aorta wall, intramyocardial membranous layer, and renal interstitial in the group of rabbits which were irradiated with laser and accompanying with oxygen inspiration, This experimental result is significa -nt for clinical application. The results of clinic application showed, that the patients employed this method which treatment cerebral infarction, lipohemia, the perfect effect 30.6%, effective ratio 61.1%.

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LOW LEVEL LASER THERAPY RESPONSE IN PATIENTS WITH CHRONIC LOW BACK PAIN. A DOUBLE BLIND STUDY.

Soriano,Fernando; Ríos,Roxana. II Cathedra of Internal and Therapeutic Medicine . School of Medicine.National University of Rosario. Rosario. Argentina.

Patients of more than 60 years of age and with lumbar pain of more than 3 months of evolution were studied. Medical files, physical examination, laboratory analysis and x- rays were performed. Patients with: 1) suspicion of tumor, infection, gout, Paget's disease or colagen disease, 2) symptoms or signs of neurological deficit in the lower limbs, 3) use of long action corticoids took within the last thirty days were excluded. A wash up period of 5 days of NSAID was done. During the study the use of NSAID, corticoids, lissive drugs, or physistric measures were not permited. Patients were ambulatory. Two groups were randomized: A and B. Patients in group A were irradiated with Galium Arsenide Laser (Ga As), wavelength 904 nm, peak power 20 W, average power 40 mW, pulsed, pulsed emission 200 nsecs, frequency 10.000 Hz. Punctual technique was applied in the pain area with doses of 4 Joules/cm2 per point. Group B was irradiated with an equipment of the same characteristics but with a deactivated emission. The operator and patient were not aware of this situation. Ten consecutive sesions were done, one every day. Pain was evaluated through an analogical and visual scale at the beginning and the end of the treatment. Pain relief and efficacy to the therapeutic response were taken into account (pain relief more than 60%). A follow up was done during 6 months. Group A evaluated 38 patients and group B 33. Both groups were stadistically comparable. Treatment was effective in 71.06% of patients of group A and in 36.37% of group B ($p < 0.007$). The pain disappeared completely in 44.74% of group A and 15.16% of group B ($p < 0.01$). During the follow up 34.78% of the patients of group A that had relieved their pain more than 60% relapsed, and the relapse percentage in group B was of 70%. No cutaneous or ophtalmologic side effects were observed. These results suggest that the irradiation with Ga As Laser in the doses and techniques applied relieves chronic low back pain in older patients in an important percentage without causing side effects.

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EFFECT OF LOW ENERGY LASER THERAPY ON HERNIATED LUMBAR DISCS

Marcos Gruszka, Walter Amryn, Rebeca Fiszerman, Jorge Pucineri, Analía Soerensen and Oscar M. Noguera. Clínica Villa Gessell, Buenos Aires Laser Center, CEDIT S.A. and Asistencia Diagnóstica, Argentina.

Laminectomy and percutaneous laser disc decompression are surgical treatments for lumbar discs herniation. Conservative therapy with physical therapy with CAT scan diagnosis before and after treatment improved symptoms but CAT scans had not changed.

We treated 15 patients with 1 or more protruded lumbar discs herniation with low energy GA-AS laser 904 nm wavelenght with a dose of 9 Joules/cm^2 on each point, 20 to 25 points, on lumbar spine and on referred radicular pain, 3 to 5 times a week during 4 months. Before and after treatment we evaluated pain, gait, neurological examination, EMGs and CAT scans.

Results: pain relieved 100%, gait and neurological signs improved in all the patients, EMGs improved and CAT scans showed less protrusion of the herniated discs. After treatment one patient 24 years old the EMG showed collateral reinnervation of right L5-S1 and the CAT scan a smaller and calcified herniated disc.

With this preliminary clinical results, low energy laser therapy promise to be a tool as conservative treatment of disc protrusion at the lumbar spine with radicular pain.

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TREATMENT OF RHEUMATOID ARTHRITIS WITH LOW ENERGY NEODYMIUM:YAG LASER

John A. Goldman, Emory University School of Medicine, Atlanta, Georgia. Yvonne Johnson, Meredith Lee, Atlanta, Georgia. Gary Bellinger, Dallas, Texas.

High and low energy lasers have been used to treat a variety of musculoskeletal conditions including rheumatoid arthritis with variable success. This investigation treated people with rheumatoid arthritis with a Neodymium:YAG laser having a continuous four to ten watt output in the infrared range. People with symmetrical involvement of their hands were lased on one side and sham lased the other side. The treatment program included lasing for ten days with evaluations done at mid point (after five days) and at the end. Measurements included grip strengths, Health Assessment Questionnaire (HAQ) scores and visual analogue scores. The initial group included thirteen people (1 man and 12 women), with an average age of 48 years. Three did not complete the program. Grip strength changed from –2 to + 10 mm Hg. with an average improvement in both the true and sham lased groups of 2.65 mm Hg. The pain index saw improvement as a whole of lessening of the pain score by 0.103 points [range –0.86 (drop in pain score) to +.07 (worsening of the pain score)]. Those who got worse increased their pain score from 0.02 to 0.50 pain points, while those who improved dropped their pain scale from 0.04 to 0.86 pain units. The HAQ score showed a drop in impairment of performing daily function by .145 points (total score range is 0 to 3.0). Those who got worse increased their impairment index by 0.50 points, while those who improved ranged from 0.125 to 0.675 points. Two stayed the same. One half the people treated felt they improved. The participants did not always correctly identify the side being lased. The use of low energy laser at the parameters used in this study does show mild improvement in some patients.

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LOW INTENSITY LASER IRRADIATION IMPROVES SKIN CIRCULATION IN PATIENTS WITH DIABETIC MICROANGIOPATHY

Andreas Schindl, M.D[1]; Martin Schindl, M.D[2]; Heidemaric Schön[3], M.D; Robert Knobler[1], M.D; Liesbeth Schindl, M.D.[2]

[1] Department of Dermatology, Div. of Special and Environmental Dermatology, University of Vienna Medical School, Waehringer Guertel 18-20, A-1090 Vienna, Austria
[2] Institute for Lasermedicine, Rathausplatz 4, A-3400 Klosterneuburg/Vienna, Austria
[3] Department of Dermatology, Div. of Immunology, Allergy, and Infectious Diseases, University of Vienna Medical School, Waehringer Guertel 18-20, A-1090 Vienna, Austria

Diabetic foot problems due to microangiopathy account for 50% of all nontraumatic amputations. Low intensity laser irradiation has been shown to induce wound healing in conditions of reduced microcirculation. We investigated the influence of laser irradiation on skin blood flow in patients with diabetic microangiopathy.
Thirty patients with diabetic ulcers or gangrenes and elevated levels of glycosylated hemoglobin were randomized by blocks of two to receive either a single low intensity laser irradiation with an energy density of 30 J/cm² or a sham-irradiation over both forefoot regions in a double-blind, placebo-controlled clinical study. Skin blood flow by means of temperature-recordings over forefoot region was detected by infrared-thermography. Following a single transcutaneous low intensity laser irradiation a statstically significant rise in skin temperature was noted ($p<0.001$ by ANOVA for repeated measurements) whereas in the sham-irradiated control group a slight but significant drop in temperature ($p<0.001$) was found.
The data from this first randomized, double-blind, placebo-controlled clinical trial demonstrate an increase in skin microcirculation due to athermic laser irradiation in patients with diabetic microangiopathy.

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LASER BIOMODULATION: APPLICATION OF THE GALLIUM-ARSENIDE LASER IN THE THERAPY OF ULCUS CRURIS

Tanja Škorić, Gordana Tonković, Mladen Tršinski, Neven Žarković
Medical Centre "Medvešćak" and "Rudjer Bošković" Institute, Zagreb, Croatia

Already of a longer time low-power lasers have a widespread clinical use, especially in the treatment of diseases accompained by pain (neuralgia, musculosceletal degenerative diseases and sport injuries), as well as in therapy of varicose, posttrombotic ulceration, radionecrosis and decubital ulceration.
Due to the experimental results on the influence of laser on cell-cultures and healing of the skin-defects in mice, affecting pain perception, tumor growth and immunity, novel Gallium-Arsenide (GaAs) laser, was used in the experimental therapy of ulcer cruris. Before the laser application ulcers were unsuccessfully treated with conservative therapy)on average for about 4 months). According to the allowance of the Ethical Committee of the Medical Centre, ten patients with hypostatic crural ulcers were treated with pulsed GaAs semiconductor "Labis" (LAIR Zagreb) 50W peak power, 905 nm wavelength. Irradiation lasted 210 s daily (energy density 1.05 J/cm2), two times per week, during 7 consecutive weeks. Complete epithelisation of the lesion was obtained in 4 out of 10 patients, whil in all other patients ulcers became smaller (minimal decrease was 4% and maximal 52%). The data obtained are emphasising the application of GaAs laser in the therapy of ulcus cruris as a useful and harmless therapeutical method.

CARDIOVASCULAR

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NEW CAPABILITIES OF SPECTROSCOPY IN CORONARY DIAGNOSE APPLYING AUTOMATED AND COMPUTERIZED AIDED SOFTWARE.

M.Cristina Chavantes*, Hassan Sidaoui, Orion O. Silva, Renato Zangaro, Sokki Sathaiah, Landulfo Silveira Jn, Carlos A.G. Pasqualucci#, Marcos T.T.Pacheco.
Research and Development Institute of UNIVAP,
Medical Laser Center Incor, Pathology Department MS, USP#, Brazil.*

Background/Purpose: Currently, in the clinical field there is no reliable method of determining plaque chemical composition in vivo, especially in restenosis, or in early asymptomatic phase, such as fatty streaks. The goal of this study was to develop computerized automated spectra analysis for Raman Spectral guided Laser Angioplasty system, that enables the rapid analysis of the spectral data, based on the spectrum signature of each case, thus the true nature of the tissue can be determined.
Study Design (M/M): Near Infrared Raman Spectroscopy (NIRS) provides a powerful less invasive method for the analysis of biochemical composition of human artery coronary tissues. The optical diagnosis is done through the development of a complex software, that applies a "Fuzzy Sets Theory" and "Belief Theory". The first one is useful to handle incertitude's parameters, the second is based on the differences between the analysed unknown tissue Raman spectrum and the standard. Initially, the standard spectrum identifies a specific pathology or non pathological tissue condition. In order to validate the

diagnosis inferred by the automated system, a collection of 70 spectra obtained from freshly post-mortem human coronary samples have been studied.
Results: Such technique can discriminate between normal, atheromatous and calcified human coronary tissues. The overall intensity of Raman spectra of Ca^{++} plaque is 5 to 20 times more intense than normal tissue and 2 to 10 times more intense than an atheromatous plaque. The spectrum tree allows a good correlation between Raman spectrum and histological results for both used approaches.
Conclusion: Computer analysis of spectroscopic imaging provides and an objective accurate, sensitive and realible assessment (w/ quantification), to true diagnostic making, through specific flow-chart. The employed technique has 95% to 98% of liability on identification of analysed spectra. This is a new technique of real time diagnosis which applies Artificial Intelligence resources, and it can give an accurate optical biopsy of coronary artery studied tissues. Thus, automated spectral analysis can be an invaluable asset to the physician in determining the nature of tissue with a conclusive diagnosis for each case.

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SENSITIVITY ANALYSIS OF TEMPERATURE VARIATION AT CAROTID ARTERY ANASTOMOSIS SITE

Colette Cozean, Ph.D., Irvine, California
Rolf Kojima, Irvine, California

Real time temperature feedback systems have been developed to maintain optimal welding temperatures. Assuming an optimal welding temperature in the range of 50 - 70° C using a 1.32μ Nd:YAG, studies were performed to determine the sensitivity of various laser dosimetries and control of these parameters in order to allow the laser alone to precisely control temperature at the tissue. If the laser parameters including power, duty cycle, pulse width and pulse shape can be set in such a way to reduce the sensitivity of the system to surgeon capability and variability, the cost and reliability of a system required for temperature feedback could be eliminated or provide a redundant control.

Power settings of .5, .6, .7, .8, .9, 1.0, 1.5 and 2.0 watts were tested over 50 seconds of firing with temperature measurements taken in one second intervals up to 5 sec, 5 sec. intervals up to 20 sec. and 10 sec. intervals thereafter. It was shown that within 3-5 sec, the tissue reaches anastomosis temperature and that temperature can be maintained within ±3° for the period to time tested. Results were confirmed using bursting pressure studies of interrupted sutures vs. laser groups over 28 days and blood flow measurements pre and post treatment. Endoscopic views of the vessels were also obtained demonstrating that the laser anastomosed site preserved the lumen diameter as compared to the restricted lumens resulting from accumulation of inflammatory cells at the suture sites.

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LASER-INDUCED FLUORESCENCE DETECTION OF RAT AORTIC ALLOGRAFT VASCULOPATHY.

Christov, A., Dai, E., Liu, L.Y., Miller, L., Nash, P., Lalani, A.S., McFadden, G., Lucas A.R.
J.P. Robarts Research Institute, U.W.O., London, Ontario, Canada

Transplant vasculopathy is a diffuse form of atherosclerosis produced after cardiac transplant by ischemic and inflammatory injury. Atherosclerotic coronary disease is the leading cause of organ loss after the first year post cardiac transplant. We have examined laser-induced fluorescence (LIF) as a diagnostic tool for the detection of intimal hyperplasia and mononuclear cell invasion in a rat model of aortic allograft transplant. In order to study LIF spectra in rat aortic segments with varying degrees of intimal hyperplasia and rejection, sections from control arteries and arteries treated with viral anti-inflammatory proteins were compared. SERP-1 (a virus-encoded anti-inflammatory glycoprotein) has been recently reported to reduce plaque development in cholesterol fed rabbits, after balloon angioplasty. We have investigated the effects of transplant vasculopathy and inflammatory cell invasion on laser-induced fluorescence (LIF) recorded from rat aorta. 34 Sprague Dawley (SD) rats had Lewis (L) rat infrarenal aortic allograft transplant under general anesthetic. Rats had infusion of saline or SERP-1 at doses ranging from 0.3, 3, 30 and 300 ng by injection via tail vein. Six SD to SD and two L to L transplantations were used as controls for aortic graft surgical injury. Rats were sacrificed at 28 days post surgery for LIF and morphometric analysis. LIF spectra were recorded from the inner surface of the aortic implant during excitation at 308 nm. The fluorescent intensity at 400-430 nm was lower in rats with reduced intimal hyperplasia (SERP-1) on comparison with the saline and SD to SD controls ($p<0.05$). Compared to the saline controls fluorescence emission at 406 nm, 420 nm and 432 nm in areas with reduced inflammatory cell infiltration after SERP-1 treatment was decreased. A correlation ($R^2=0.797$) between LIF intensity at 406 nm and the effect of 0.3 ng SERP-1 on aortic morphology was found. Conclusion: Transplant associated intimal plaque formation and inflammatory cell infiltration are detectable by characteristic changes in LIF spectral emission during 308 nm excitation.

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LASER INDUCED FLUORESCENCE: RECOGNITION OF THE STRUCTURAL COMPOSITION OF PORCINE VALVES.

Christov, A., Dunmore-Buyze, J., Boughner, D.R., Lucas A.R.
J.P. Robarts Research Institute, U.W.O., London, Ontario, Canada

Reconstruction and replacement of heart valves with grafts manufactured from pig and human tissue is becoming a common surgical procedure. However, bioprosthetic valves wear out in a shorter time span than mechanical valves. At present there is no method to examine the structure of a tissue valve and evaluate potential sources of eventual structural breakdown prior to implant. Pre-surgical analysis of tissue might allow detection of potential structural flaws in the tissue avoiding long-term valve failure. Laser induced fluorescence (LIF) of natural fluorophors is an elegant method for the study of plaque formation, growth and rupture in vascular tissues, as well as for the detection and treatment of tumors. We report here a study of LIF as a potential diagnostic approach for analysis of valvular tissue prior to use in clinical implants. Using a Spectranetics XeCl AIS Dymer 200+ laser (coupled to an OMA) for fluorescence excitation and detection, we studied natural fluorescence at both surfaces and the glycosaminoglycan/lipid containing layer of the aortic, mitral and pulmonary valves from 3 pig hearts (9 valves). Inequality between the LIF of the layers in the aortic and mitral valves was found. The inner layers of the aortic valve leaflets exhibit higher fluorescence, when compared with the aortic surface (collagen I and III) and the ventricular surface (elastin) of the leaflets. Also the aortic side appears to exhibit less fluorescence intensity than the ventricular side (for 390 to 420 nm, $p<0.02$). Similar differences were detected in LIF recorded from the mitral valve at 390 nm ($p<0.001$), 400 nm, and 410 nm. No specific response to 308 nm excitation was found in the LIF spectra recorded from pulmonary valves. The differences observed in the aortic and in the mitral valves may be due to diversity in the structural protein content and spatial distribution of naturally fluorescing compounds. We postulate that valve surface LIF is changed by collagen and elastin content. Our results suggest that LIF can be successfully applied as a diagnostic probe of tissue valve structure prior to use for implantation.

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LASER INDUCED ENHANCEMENT OF t-PA MEDIATED FIBRINOLYSIS

On Topaz, Clifford Morris, Anthony J. Minisi, PK Mohanty, Marc Carr.
Medical College of Virginia, Richmond, Virginia, USA

Background: Thrombi have a high water content avidly absorbing laser

energy. The holmium:YAG laser operates within strong water absorption peaks. It is not known whether this laser's energy combined with thrombolytic therapy can enhance the rate of fibrinolysis.
Methods: 3 in-vitro experimental protocols were used: **I:** Fibrin clots were treated with 116000 IU t-PA for 1,6,12 hours (hs), respectively, at which time, they were exposed to laser energy (holmium:YAG, 2.1 micron wave-length). **II:** Fibrin gels layered with t-PA were exposed to either 25, 50, 75 or 100 Joules (J) laser energy. t-PA was then allowed to interact for an additional 4 hs. **III:** The effects of varying clot age (1,4 or 8 hs) on laser's (75J) augmentation of t-PA induced fibrinolysis were tested. Fibrin degradation products (FDPs), an indicator of fibrinolysis, were measured by latex agglutination.
Results: In fibrin clots exposed to t-PA for 6 hs, the addition of laser energy significantly increased FDPs released (t-PA alone 40±0mcg/ml, laser plus t-PA 160±0mcg/ml, p<0.001). For gels exposed to t-PA for 12 hs, addition of laser energy resulted in complete dissolution of the clot (FDPs with t-PA alone 160±0mcg/ml vs. laser plus t-PA >300 mcg/ml, p=0.001). The rise in FDPs was significantly greater with 75J of laser energy compared to 25J (160±0mcg/ml vs 80±0mcg/ml, p=0.0001), however, energy levels greater than 75J did not further increase the amount of FDPs indicating a plateau phenomena in dose-response relationship. t-PA had decreased fibrinolytic effect on 4 and 8 hs old clots (FDPs of 60±20mcg/ml and 30±10mcg/ml, respectively). Laser energy reversed this trend and enhanced fibrinolysis in both 4 and 8 hs old clots. In 4 hs old clots, laser plus t-PA resulted in FDP release of 160±0mcg/ml compared to 60±20mcg/ml for t-PA alone (p=0.007). In 8 hs old clots, FDP release with laser plus t-PA was 160±0mcg/ml compared to 30±10mcg/ml with t-PA alone (p=0.0004). **Conclusions:** In-vitro application of mid-infrared laser energy significantly enhances fibrinolysis in fibrin clots initially treated by t-PA. The in-vitro interaction between mid-infrared laser and t-PA is energy dependent, however, at energy levels exceeding 75J there is a plateau phenomenon in dose-response relationship. This wave-length laser energy also augments the decreased response of aging clots to t-PA.

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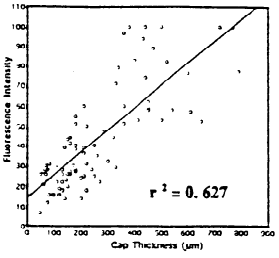
PREDICTING ATHEROMATOUS PLAQUE VULNERABILITY by FLUORESCENCE ANALYSIS

Alejandro Prieto, Ruiping Huang, George S. Abela
Dept. of Medicine, Michigan State University,
East Lansing, MI 48824

Atheromatous plaques that are vulnerable to disruption and thrombosis have been shown to have a thin fibrous cap and a lipid-rich yellow core. Plaque cap thickness has been correlated to yellow saturation by performing quantitative colorimetry analysis on digitized angioscopic images. In this study we correlated plaque cap thickness to laser induced fluorescence intensity and to direct colorimetry measurement. Methods: A lipid emulsion mixed with β-carotene was injected into the subintima of a segment of lamb aorta to simulate the lipid core of an atheromatous plaque. Colorimetry analysis was performed by measuring the percent yellow saturation of the plaque sample using the tristimulus method. Fluorescence of the sample excited by a 488 nm laser beam was measured using a multi-channel analyzer system. After color and fluorescence measurement were obtained the plaques were frozen and then cut perpendicularly at the center. The average thickness of the cap was measured using light microscopy. Results: Fluorescence was highly correlated with cap thickness and inversely correlated to percent yellow saturation (r^2=0.627 and r^2=0.789 respectively; p<0.0001). Conclusion: Plaque cap thickness can be estimated by laser induced fluorescence. This may be potentially useful in detecting plaques that are vulnerable to rupture.



DENTISTRY

41*

PHASE IIB CLINICAL RESULTS IN 125 PATIENTS COMPARING THE LASER AND THE DRILL FOR CAVITY PREPARATION

James Pelagalli, DDS, Independence, Ohio
Craig Gimbel, DDS, Hewitt, New Jersey
Richard Hanson, DMD, Fullerton, California
Alan Swett, DDS, Johnston, Iowa
David Winn, II., DDS, Colorado Springs, Colorado

The purpose of this study was to evaluate the ability of the Er:YAG laser, as compared to the drill, to remove caries and form a preparation in which an adequate restoration could be placed. The study was performed at three clinical sites. Two blinded evaluators assessed the completeness of caries removal, the adequacy of the cavity preparation, the restoration immediately post-operatively and at three months the pulpal vitality was also assessed in the treated teeth prior to treatment and at three months postoperatively.

Patients were randomly assigned to either the laser or drill treatment groups. Eighty-six percent of patients treated returned for follow-up. Change in pulpal vitality for the laser group and the control group was not significant. In 100% of the cases, in both groups, all caries was removed, the cavity was adequately prepared and the restoration met acceptance criteria. The laser treated patients required no anesthesia. In this study, the laser compared favorably to the drill for cavity preparation.

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SEM and Dye Penetration Comparison of Er:YAG Laser vs. Traditional Treatments for Caries Prevention and Tooth Restoration. Leo J. Miserendino, UIC College of Dentistry, Wenske Laser Center Chicago, Illinois. The objectives of this study were: (I) to characterize the surface modifications to human enamel following etching in preparation for pit and fissure sealing and bonding of composite resin restorations; and (II) to compare leakage patterns around sealants and bonded restorations. A total of 44 human teeth scheduled for extraction for orthodontic, periodontal or other reasons were treated in situ either for (a) caries removal, cavity preparation, and restoration; or (b) enamel etching for pit and fissure sealing. The teeth were randomly devided into one of two treatment groups: (A) Er:YAG laser and (B) Phosphoric acid (37%) or dental high speed drill. In part I the teeth were extracted without sealing or restoration prior to SEM examination. Following standard procedures for SEM analysis the teeth were evaluated for evidence of temperature induced damage including surface charing, cracking or recrystalization of enamel, and to evaluate surface morphology including topography, roughness and debris. The effectiveness of etching or cavity preparation was then scored based on the above criteria for comparison. In part II the teeth were sealed or restored prior to extraction and measurement of marginal leakage. Following emersion in 2% methylene blue dye for 24 hours, sections were made with a diamond saw vertically through the treated fissures or restorations and four measurements made of the exposed surfaces using a measuring microscope (10X) to determine the extent of dye penetration. Mean values and standard deviations were calculated for each specimen, and compared by ANOVA

(α=0.05). The results indicate that laser interaction with enamel and dentin did not induce thermal damage in the form of cracks, charing nor recrystalization. Marginal leakage around pits and fissures and restorations were found to be statistically equivalent between the two treatment modalities. Based on these obseervations the authors conclude that Er:YAG laser treatment of pits and fissures and for cavity rpeparation is a viable alternative to traditional methods.

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Histologic Effects of Er:YAG Laser on the Human Dental Pulp.
Leo J. Miserendino, University of Illinois at Chicago College of Dentistry, Wenske Laser Center Chicago.
The purpose of this study was to compare the histologic effects of Er:YAG laser cavity preparation; caries removal, and enamel etching to traditional methods. Seventy-six specimens of human teeth were treated by the laser or dental drill for caries removal and cavity preparation in enamel and dentin; or enamel etching by the laser or phosphoric acid in vivo. The teeth were later extracted for periodontal, orthodontic or prosthetic reasons at 3 time intervals: (1) Immediate; (2) 24-48hrs; or (3) 1-13mos. post treatment. The histologic effects on dentin; pre-dentin; Odontoblasts; pulp tissue and vasculature were rated as 0=absent; 1=mild; 2=moderate; or 3=severe and compared for both treatment modalities (laser vs. control) and each of the procedures (enamel etching, caries removal, and cavity preparation). Statistical analysis of the data (ANOVA α>0.05) revealed no significant differences between the two treatment methods, laser or control; nor for the 3 procedures. The most frequent short term (0-48 hr) histologic effect was mild to moderate hyperemia (Laser =0.57 vs. Control =0.70). Long term effects for both treatment groups suggest normal pulp healing and repair mechanisms occur with equal frequency. The incidence of pulp necrosis was slightly greater in the control group (Laser=0.03 vs. Control =0.27) but was not statistically significant. The effects on pulp vitality by both methods appeared to depend on the proximity of caries to the pulp and thickness of remaining dentin as reported by others. The results suggest that Er:YAG laser effects on dentinal tissues and pulp are similar to conventional methods for treatments of caries removal, cavity preparation, and enamel etching.

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EFFECT OF SHORT PULSE WIDTHS (120 FS - 20 PS) ON LASER ABLATION OF TISSUE
B.-M. Kim, , M. D. Feit, A. M Rubenchik, M. D. Perry, B. C. Stuart, and L. B. Da Silva
Lawrence Livermore National Laboratory, Livermore, CA

Ultrashort pulse laser (USPL, <1.0 ps) tissue ablation is advantageous because of its high ablation efficiency and minimal collateral damage to the surrounding tissue. However, USPL systems remain relatively large in size and expensive. For this reason it is important that we determine an optimum pulse width which minimizes collateral damage without overly complicating the laser system. In this study we measured the ablation efficiency and observed crater quality as a function of laser pulse width, which varied from 120 fs to 20 ps. The laser, operated at 790 nm, could achieve output energies of 1.0 mJ per pulse at 1 kHz. The ablation threshold was measured for-both soft (aorta) and hard tissues (tooth) using pulse widths of 120 fs - 20 ps. The ablation thresholds vary from 0.45 to 1.7 J/cm^2 for the shortest and the longest pulse widths respectively for soft tissue and from 0.45 to 0.8 J/cm^2 for hard tissue. The ablation criterion was an audible ablation "crack" for soft tissue and visual plume formation for hard tissue. The crater quality in ablated tooth using intensity 20 times higher than threshold showed no discernible differences over this range of pulse widths. There was no visible cracking or charring which is normally seen with much longer pulse (1 ns) ablation. Effects of repetition rate on ablation and crater formation have been observed. Details of these experiments will be discussed in light of optimization of laser system parameters.

* Work performed at Lawrence Livermore National Laboratory under the auspices of the U.S. Department of Energy under contract No. W-7405-ENG-48.

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TOOTH WHITENING WITH LASERS: A CASE REPORT
S M Petruska, Pittsburgh, PA
One in-office visit is used to accomplish rapid bleaching of teeth with laser activated hydrogen peroxide.
This case report will illustrate the procedure using an Argon Laser and a CO2 Laser.
The results show significant whitening of teeth calibrated on a Vita shade guide.
This comfortable procedure yields high patient satisfaction.

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VASCULAR LESIONS OF THE ORAL CAVITY
Harry P. Pasqual, D.M.D.
University of Pittsburgh Medical Center
Selective Photothermolysis of Hemangioma and Vascular malformations can be successfully accomplished frequently in one treatment with the 585NM Flashlamp pumped dye laser. These vascular lesions of the tongue, lips and mucous membrane can be involuted and deeper penetration is required. Persistant lasing will create ulceration but with no blood loss compared to conventional steel blade excision. Purpura are present following ablation and the resultant ulcer will exfoliate in 10-14 days. No residual vascular presence is clinically visible. If a lesion is found to have a very thick corpus, the copper vapor laser can be used to photocoagulate this component because of its ability to increase its thermal energy. Unlike cutaneous lesions, scarring has not been a clinical or cosmetic consideration. Vascular lesions of the tongue will frequently involve both dorsal and ventral surfaces. Anatomical location, anterior and posterior, and size of the lesion can influence the treatment sequence. Staging the treatment is significant with large vascular formations. Debulking of the tumor mass is indicated when size is a significant factor, and to avoid a problem with hemostasis.

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USE OF THE CONTACT YAG LASER IN TEMPOROMANDIBULAR JOINT SURGERY. A RETROSPECTIVE OF 100 CASES.
Harry P. Pasqual, D.M.D.
University of Pittsburgh Medical Center
Since we performed our first temporomandibular joint arthroplasty with a yag laser in 1989, the contact yag

laser continues to be our instrument of choice to perform this procedure. As previously compared to a conventional means the laser provided good hemostasis with decreased affect to surrounding tissue, better visibility and a more comfortable post-operative course for the patient. Using the contact yag laser also has afforded a new way to manage internal disc derangement by means of retrodiscal scarification. The contact yag laser continues to endure the test of time as a useful instrument for this procedure.

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THE BACTERICIDAL EFFECTS OF VARIOUS LASER SYSTEMS IN ENDODONTOLOGY

A. Moritz, U. Schoop, W. Sperr
Dept. of Cons. Dentistry, Univ. of Vienna

This study aimed to examine the suitability of different laser systems for reducing bacteria in root canals. Extracted, endodontically prepared teeth were inoculated with Escherichia coli and Streptococcus faecalis in vitro. The teeth were then irradiated using different kinds of laser systems at different output powers and exposure times. In addition to the Nd:YAG-, the Ho:YAG- and the Diode laser, which are usually provided with a flexible delivery system, the Er:YAG laser was applied, too. For his kind of laser a flexible delivery system has become available recently. The evaluation of the bactericidal effect was done counting the log CFU. This bacteriological study was complemented by thermal measurements using infrared spectroscopy.

Compared to a control group, all the lasers provide a strong bactericidal effect in the root canal; especially in the case of the diode laser, with minor thermal side effects.

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SIMULATION AND EXPERIMENTAL EVALUATION OF LASER-INDUCED HEAT-DISTRIBUTION IN DENTAL HARD TISSUES

U.Schoop; A. Moritz; J. Wernisch
Dept. of Cons. Dentistry, Univ. of Vienna

The use of different laser systems in dentistry requires the quantification of alterations and modifications in different dental hard tissues in additon to the medical investigations. In this field, certain parameters like temperature, thermal conductance and the influence of the irradiation on tooth vitality are of interest. Above all, the evaluation of these parameters is absolutely necessary for a standardization of laser treatment in dentistry.

Aside from classical physical procedures for thermal measurements like the use of thermocouples or infrared spectroscopy, the integral image of thermal conductance is complemented by mathematical simulations using the method of finite elements and finite differences.

Providing the appropriate conditions for calculation, it can be shown, that the theoretically evaluated thermal distribution in the tooth during irradiation of the root canal carried out using different kinds of dental laser systems, matches very well the experimentally evaluated data.

GASTROENTEROLOGY/ GENERAL SURGERY/ GYNECOLOGY

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Interstitial Laser Photocoagulation: Physical Tissue Alterations and MRI Monitoring

Lance A. Manning, Steven E. Harms, Hamid Mumtaz, and Steven T. Flock,

Departments of Otolaryngology (L.A.M., S.T.F.), Radiology (S.E.H.), and General Surgery (H.M.), University Of Arkansas for Medical Sciences, Little Rock, Arkansas

Interstitial laser photocoagulation (ILP) has been shown to be an effective and safe therapy to treat solid cancers via the delivery of laser energy to the various target tissues. A primary advantage of this technique is the minimally-invasive nature of ILP, and in order to make the most of this benefit a likewise non-invasive, competent monitoring system should be utilized.

In first part of this study, thermal conductivity and diffusivity are measured following the heating of bovine muscle tissue and human breast tumors to various temperatures. The values recorded decreased by approximately 25% for thermal conductivity and by 68% for thermal diffusivity, after the tissues were heated. Both data subsets demonstrated large variations for each tissue sample. This section of the study showed that heat dosimetry modeling to predict the tissue changes during ILP to be difficult and unreliable. The multifactoral and dynamic nature of the treatment make modeling a poor candidate for controlling the tissue interactions. The second part of this study proposes the use of RODEO MRI real-time monitoring of ILP for the treatment of solid breast tumors. The goal of this research is to correlate the effects of ILP with pre-treatment, real-time, and post-treatment magnetic resonance images, in an effort to proceed toward clinically practical use of ILP for breast cancer treatment. For this purpose, an Nd:YAG laser was used to create lesions in MTF-7 breast tumors in living rats. The T1 weighted images taken prior to, during, and after ILP using the three dimensional RODEO MRI software. These images were compared to gross and histological inspection. The differences in signal intensity of these images during the ILP procedure were compared. The MRI signal intensity of the tumors initially decreases by 70-90%, then immediately following the treatment increase to above the initial values. This is compared to the control values of muscle and background signal intensity remain stable throughout the procedure.

The zone of MRI signal intensity changes observed in the tumors correlates well with the extent of tumor destruction and necrosis induced by the laser as they relate to real-time magnetic resonance images and histological examination. This information can be utilized to monitor the ILP effects in breast cancer patients to insure tumor death while preserving adjacent, "normal" tissue. This can prevent the disfiguring effects of the usual surgical intervention by providing a safe, effective alternative treatment for breast cancer.

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GD-DTPA-ENHANCED MRI FOR FOLLOW-UP OF LASER-INDUCED THERMO-THERAPY (LITT)

Isbert CM[1], Germer CT[1], Albrecht D[1], Ritz JP[1], Schilling A[2], Roggan A[3], Wolf KJ[2], Müller G[3], Buhr HJ[1]
[1] Department of General, Vascular and Thoracic Surgery
[2] Department of Radiology
[3] Institute for Medical, Technical, Physics and Lasermedicine

University Medical Center Benjamin Franklin Freie Universität Berlin, Germany

Purpose: To evaluate gadolinium-DTPA-enhanced MRI for follow-up monitoring of laser-induced thermotherapy (LITT) and to determine of a useful examination schedule.

Materials and Methods: LITT of the liver was performed in 55 rabbits using a Nd:YAG laser (4 w power output, 840 s exposure time). Gd-DTPA MRI and histological examinations were performed at different times (0-168 days).

Results: Laser-induced lesions underwent regeneration and volume size reduction (69% after 168 days). The correlation coefficient (MR vs macroscopic analysis) for the mean lesion diameter was r=0.96. Histology of lesions comprised the four zones that correlated best with MRI findings. Coagulation necroses immediately after LITT were seen as an area of no enhancement on Gd-DTPA MRI. Circular enhancement was first seen 72-96 hours after LITT, which was due to early proliferation of such mesenchymal cells as fibroblasts, bile duct epithelia and endothelia.

Conclusions: 1) Gd-DTPA-enhanced MRI provides precise criteria for the natural regeneration pattern of laser-induced lesions and therefore seems to be a good monitoring procedure for the follow-up after LITT. 2) MRI should be performed 24 and 96 hours after LITT.

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MAGNETIC RESONANCE IMAGING - CONTROLLED INTERSTITIAL LASER THERAPY IN CHILDREN WITH VASCULAR MALFORMATIONS

D. Cholewa[1], F. Wacker[2], A. Roggan[3], J. Waldschmidt[1]

Pediatric Surgery[1] and Radiology[2], University Hospital Benjamin Franklin, Center for Laser Medicine[3], FU Berlin, D-12200 Berlin

Congenital vascular malformations can become symptomatic due to expansive volume increase and compression of adjacent structures. Surgical therapy very often leaves a large substance defect. Interstitial laser therapy (ILT) is an alternative treatment method. High-resolution imaging is necessary for treatment control on account of the narrow anatomical conditions in children. Ultrasound (US) and color-coded Doppler sonography (CCDS) have proved very useful here but are of limited value for certain localizations and extents of the malformations. Here, MRI offers good demarcation of the malformation due to high soft tissue contrast. Additional online thermometry is possible. The development of open MR systems has considerably facilitated patient access and enables MR-assisted interventions. We report about 20 ILT applications in an open MR system in selected children with congenital vascular malformations. Needle placement is excellent. Different laser fibers and interstitial laser applicators were used. MR online thermo changes in laser tissue interaction allowed to adapt laser parameters on local perfusion in the vascular malformation.

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LASER TREATMENT OF HEMANGIOMAS OF THE LARYNX AND TRACHEA

D.Cholewa, J.Waldschmidt

Department of Pediatric surgery, University Medical Center Benjamin Franklin, Hindenburgdamm 30, D-12200 Berlin

From 1978 until May 1997, we treated 412 children with airway stenoses.

Twenty-nine (7%) of the children had hemangiomas of the larynx or the cervical and thoracic trachea. All forms were encountered: flat capillary hemangiomas, tuberonous hemangiomas, submucosal cavernous hemangiomas and extramural hemangiomas with compression of the larynx and trachea or infiltrating growth into the respiratory wall. 50% had further hemangiomas at the head, neck, trunk or extremities.

All hemangiomas were treated endoscopically with endoluminal laser application using a Neodym-YAG laser, light was transmitted by a 400µ "bare fiber". Laser treatment was done by the noncontact or contact mode and by interstitial laser thermo therapy in submucosal and extraluminal hemangiomas. The results were very good. Only two of the 29 children required a tracheostoma. All the other children were extubated. Generally, one to two sessions were sufficient. Other operative measures were not applied.

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LASER LAPAROSCOPIC UTEROSACRAL NERVE VAPORIZATION COMBINED WITH UTERINE ANTEVERSION PROCEDURE FOR DYSPAREUNIA AND DYSMENORRHEA J E Carter Women's Health Center of South Orange County, Inc. Mission Viejo, California 92691

OBJECTIVE: To describe a technique and results of laser laparoscopic uterosacral nerve vaporization together with uterine anteversion for the treatment of severe dysmenorrhea and dyspareunia. SUBJECTS: 75 women age 19 to 48 years with chronic pelvic pain, dyspareunia and dysmenorrhea seeking treatment were evaluated and treated over a 2 year period. METHODS: Laser laparoscopic uterosacral nerve vaporization was performed with the CO2 laser specifically dissecting the uterosacral nerve from 1 cm below the cervical uterine junction forming an arch across to the other uterosacral nerve with the intention of destroying primary nerve supply for pain signals from the uterus through the uterosacral complex. In addition these patient's then were treated with a uterine suspension and positioning by ligament investment fixation and truncation (UPLIFT procedure). These procedures were performed without complications in 75 patients over a 2 year span. The laparoscopic uterine anteversion procedure was performed using the Carter Thomasen 2 mm needlepoint suture passer to pass suture percutaneously and transvaginally into the extraperitoneal space and then within the round ligament. The suture then exited from the ligament near the uterus and then was retrieved by a second pass of the instrument through the fascia and within the ligament which created then a fascial bridge at the next natural exiting point of the ligament out through the inguinal canal. The ligament then folds within itself as it is pulled up by the suture which moderately anteverts the uterine position by ligament investment fixation and truncation (UPLIFT). RESULTS: For all 75 patients the pain with periods decreased from an initial 8.4 to 1.7 with 0 being no pain and 10 being the worst pain (P less than 0.01, Wilcoxon's Signed Ranked Test). Pain with intercourse decreased from 8.1 to 1.5 (P less than 0.01). DISCUSSION: When dyspareunia, dysmenorrhea or chronic pelvic pain are associated with a retroverted uterus, a combination of laser laparoscopic uterine nerve ablation (LUNA) combined with uterine anteversion by the UPLIFT procedure has been demonstrated to relieve this problem.